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Utility of External Fixation-Assisted Techniques for Treating Lower Limb Deformities in Adolescent Patients

Utilità delle tecniche assistite da fissazione esterna per il trattamento delle deformità degli arti inferiori nei pazienti adolescenti

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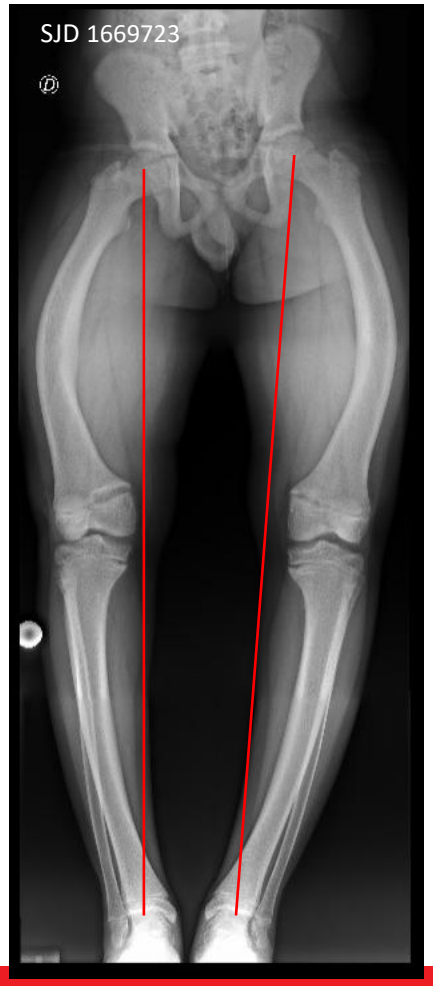
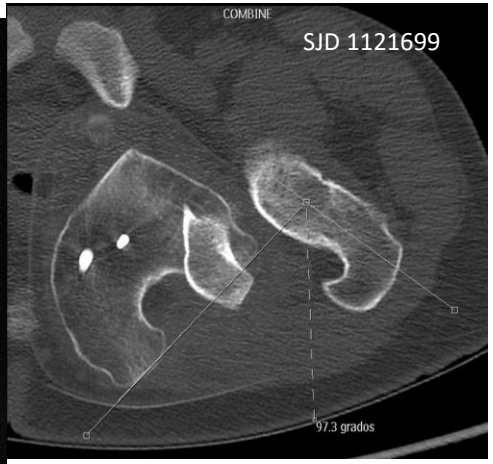
Introduction and objective

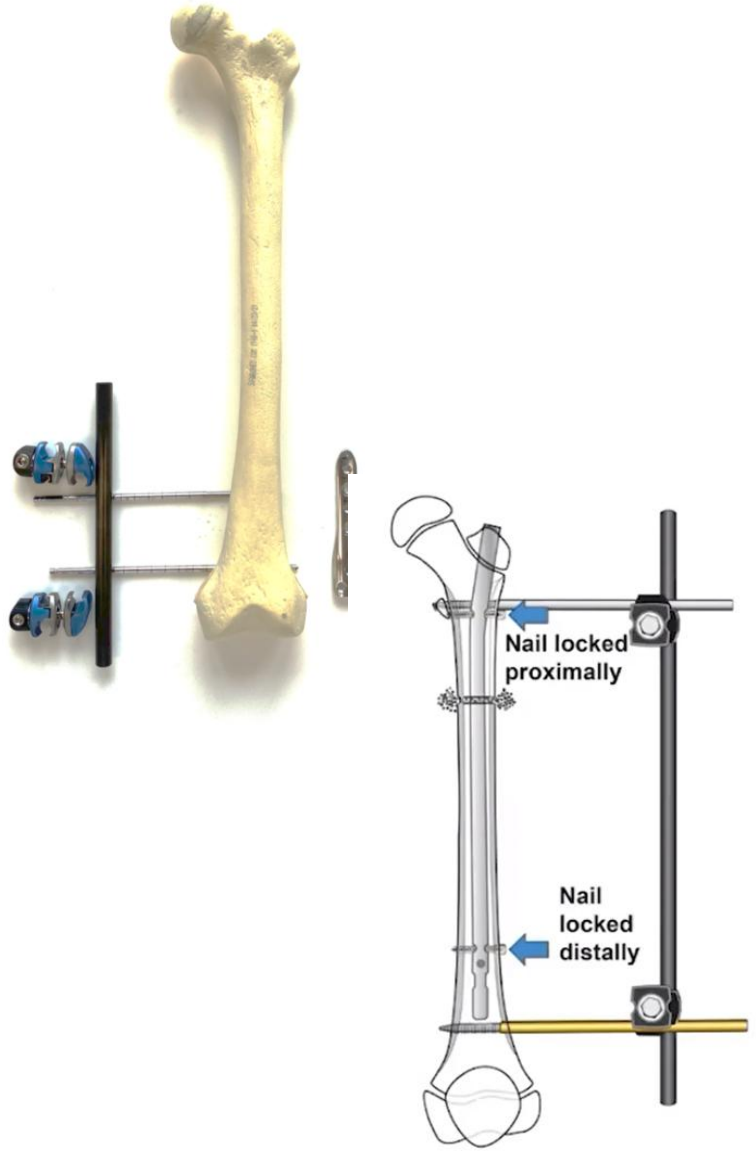
- **Uncorrected deformities** in adolescents can lead to **early joint degeneration** and **functional impairment**.
- These deformities may occur in the **frontal, sagittal, and torsional planes**.





Introduction and objective

- **FALP (Fixator Assisted Locked Plating) and FAN (Fixator-Assisted Nailing)**
  - Temporary intraoperative external fixator to maintain reduction after osteotomy
  - Internal fixation using a locked plate or nail for acute deformity correction.



Objective

- To evaluate the **efficacy** of Fixator Assisted techniques **– FALP (Fixator Assisted Locked Plating) and FAN (Fixator-Assisted Nailing) -** in achieving accurate correction of **complex femoral and tibial deformities**.

Material and Methods

- **Prospective single-center study** from **April 2021 to July 2024**
- **27 adolescent patients, 31 surgeries**
- **Data collected**:
  - Demographics, surgical time, hospitalization
  - Weight-bearing initiation, bone healing, return to daily activities
  - Radiographic and clinical outcomes

Group	Technique	Patients (n)	Bones Treated	Deformities Treated
A	FALP	20	21 femora	12 valgus, 5 varus, 3 rotational, 1 hyperextension
B	FALP	4	4 tibiae	1 flexion, 3 rotational
C	FAN	6	5 femora, 1 tibia	2 rotational (femur), 2 varus (femur), 1 valgus (femur), 1 valgus (tibia)

Etiologies of lower limb deformities

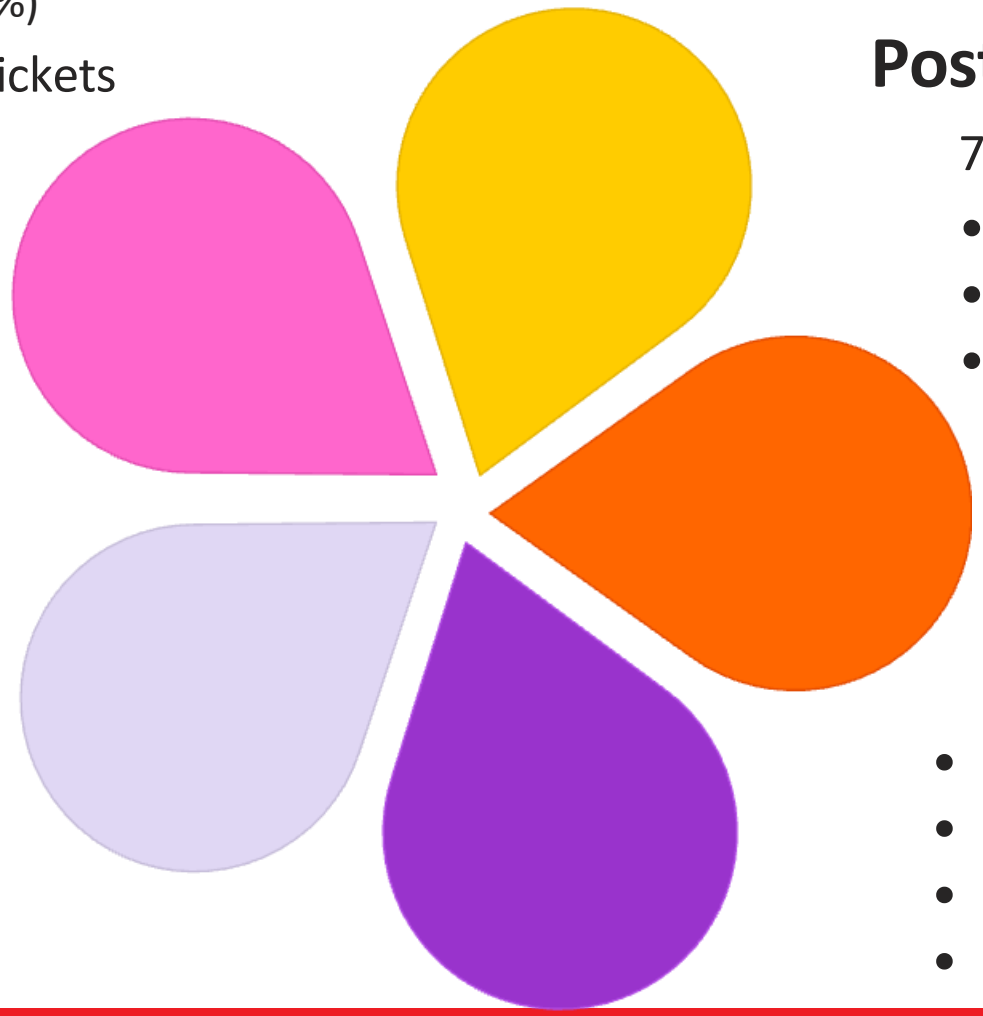
Idiopathic cases

7 cases (23%)

Bone Dysplasia

8 cases (26%)

- 4 X-linked hypophosphatemic rickets
- 2 Undiagnoses dysplasia
- 1 Ollier disease
- 1 polyostoticfibrous dysplasia



Post-traumatic cases

7 cases (23%)

- 4 Bone malunions
- 2 Early bone growth plate closure
- 1 fracture after femoral lengthening

Infections

2 cases (6%)

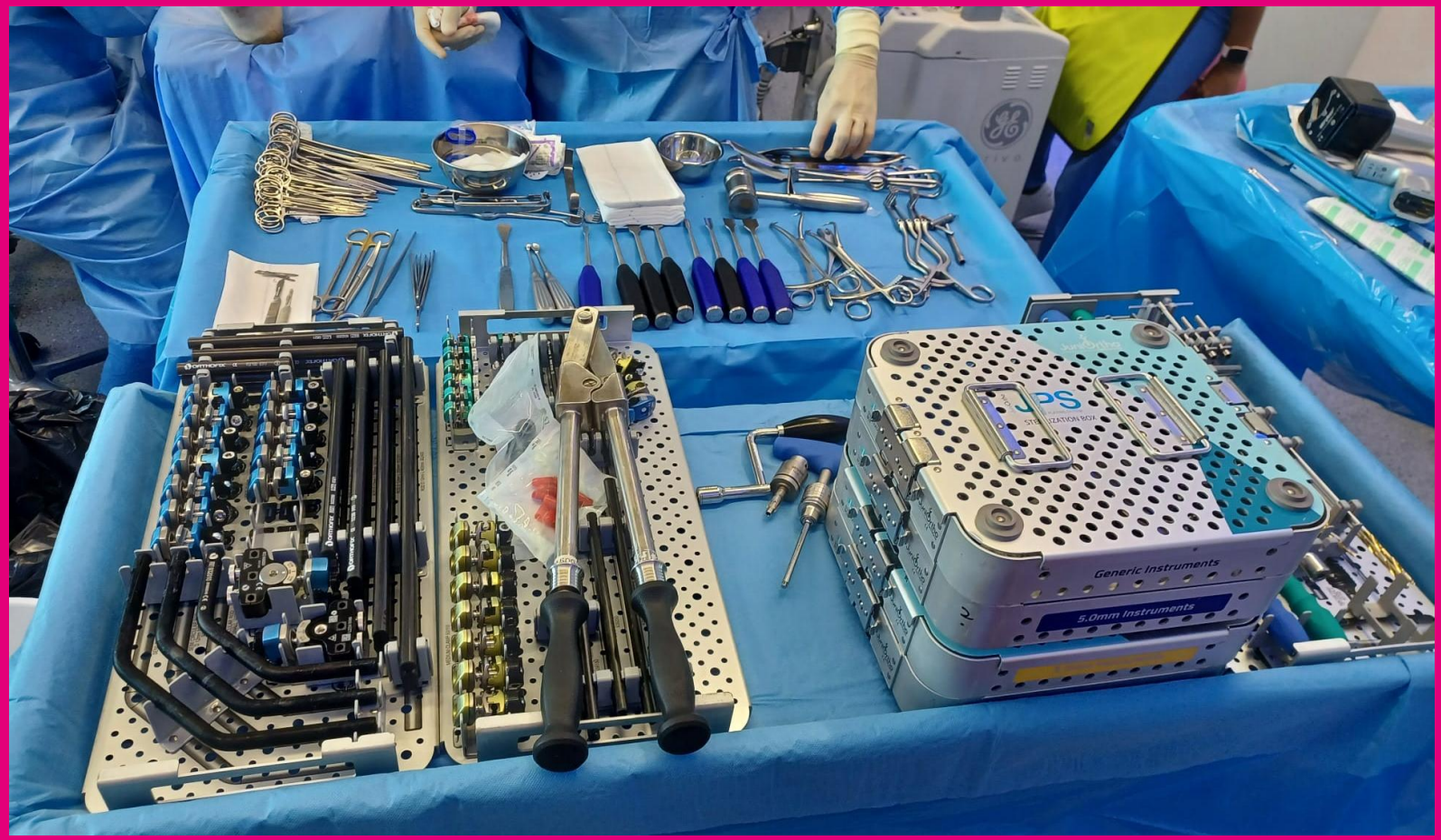
- Osteomyelitis
- Meningococcal sepsis

Other Causes

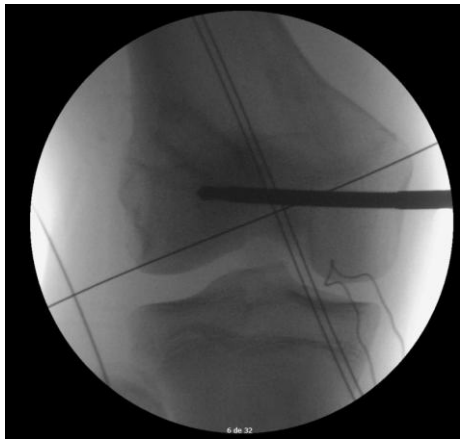
7 cases (23%)

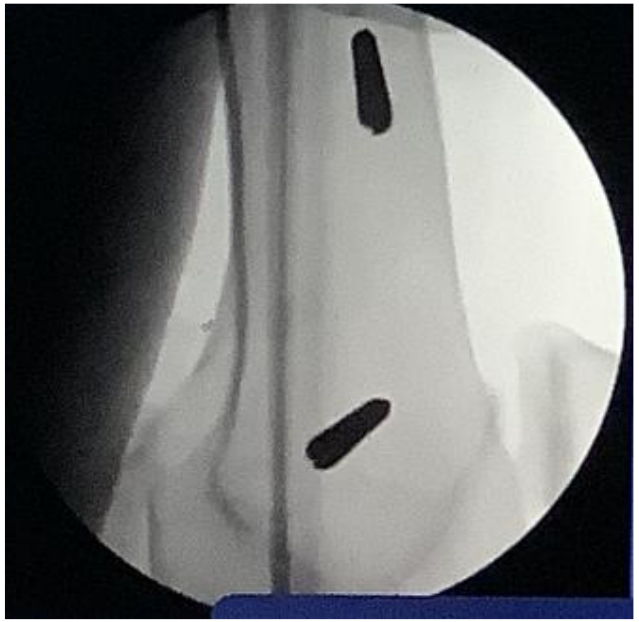
- 3 Postaxial deficiencies
- 2 Sequelae after guided growth
- 1 Popliteal pterigium syndrome
- 1 Blount's disease

Group A: Distal femur FALP technique

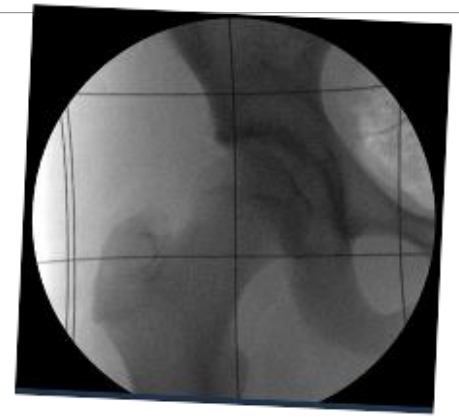


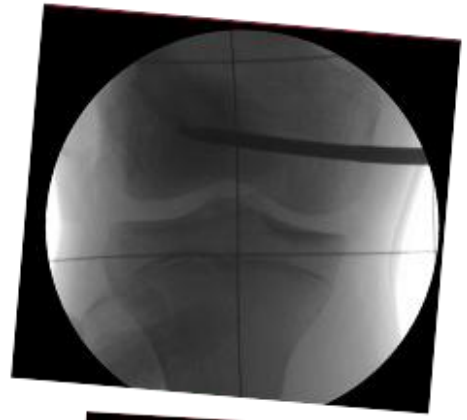
- Supine position
- Radiolucent table (X-Ray Grid)
- 2 half-pins (6mm diameter) medially inserted



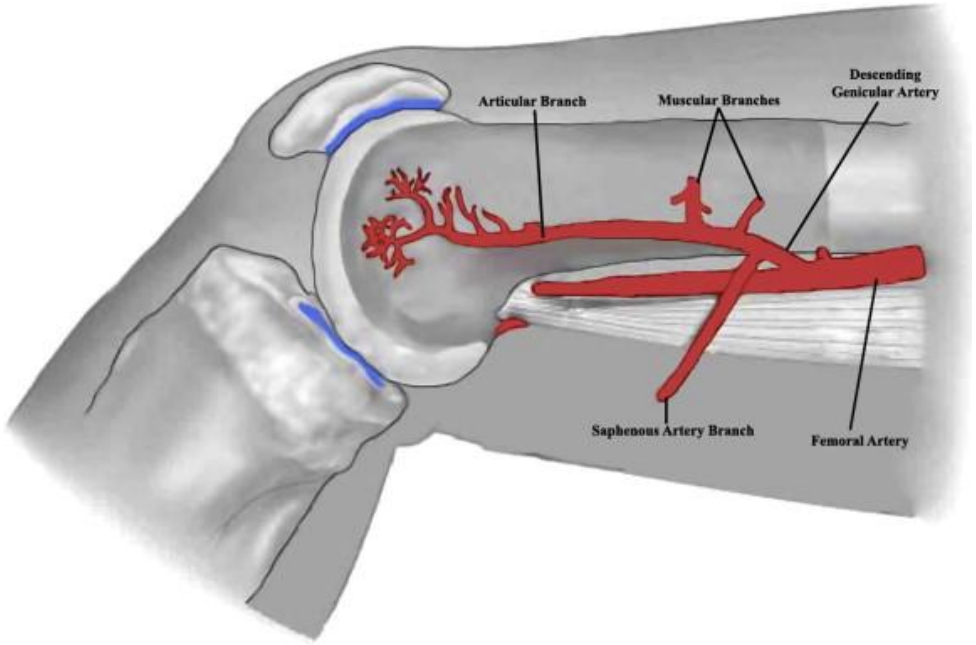


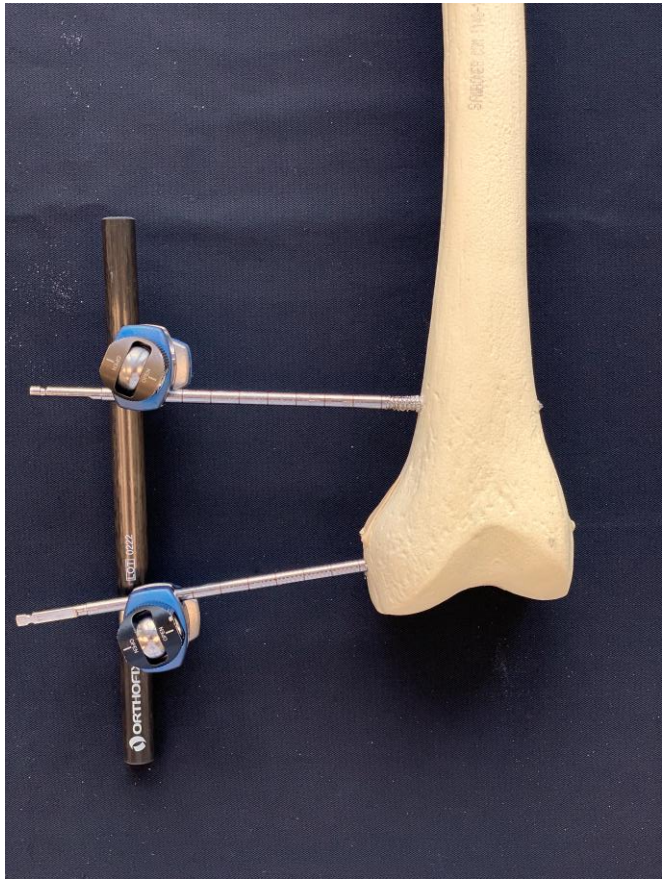
- one **distal (parallel to joint line)**
- one **proximal (perpendicular to shaft)**



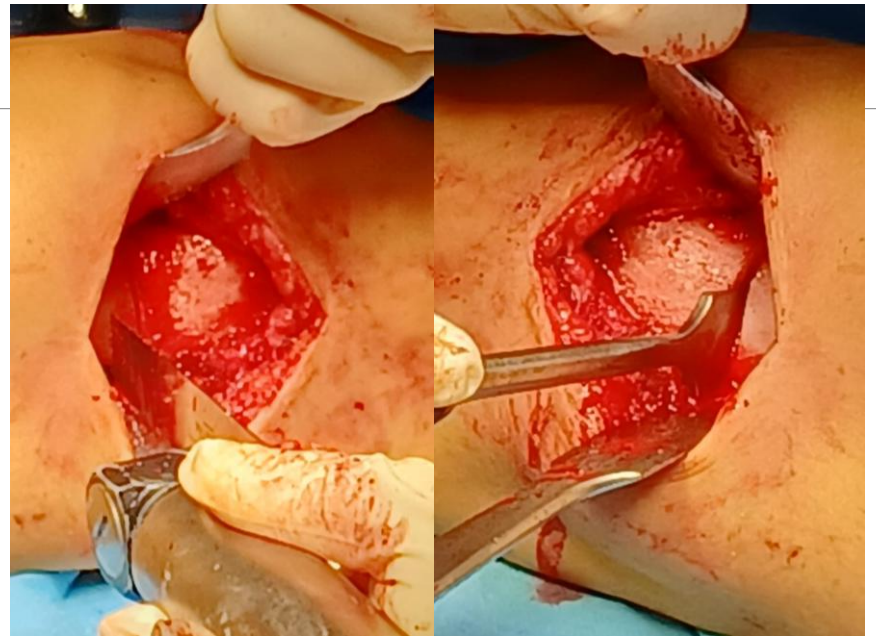


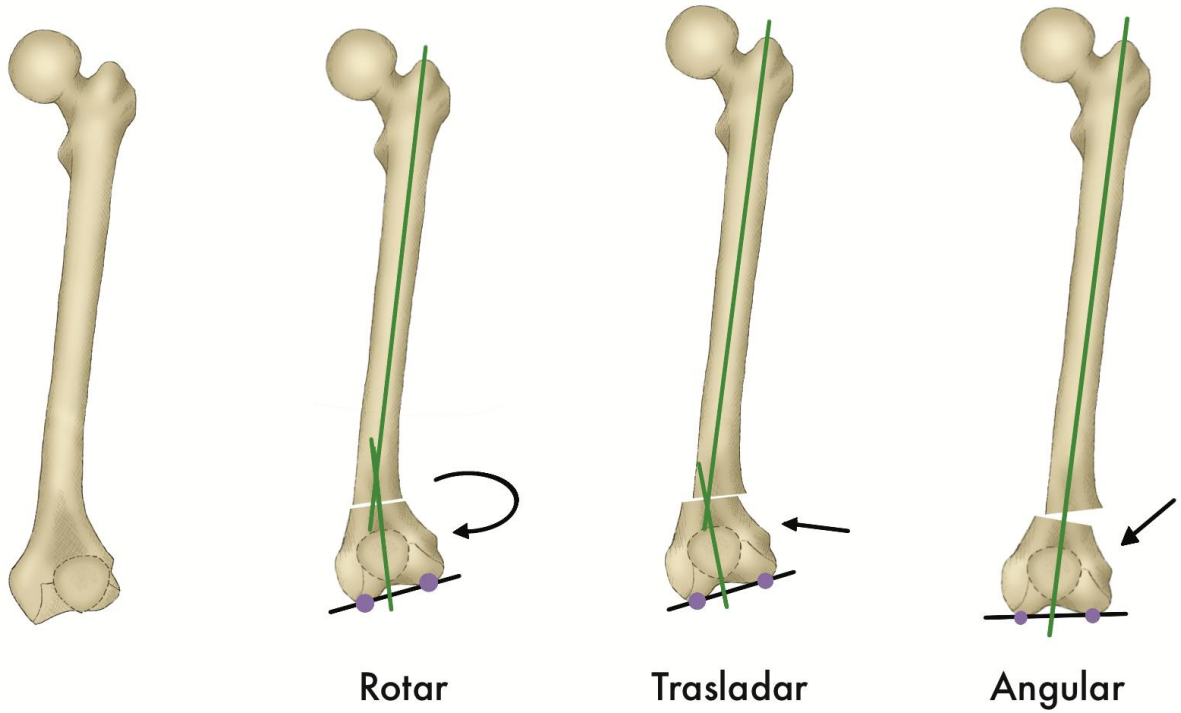
- **Pins loosely connected with monolateral external fixator**



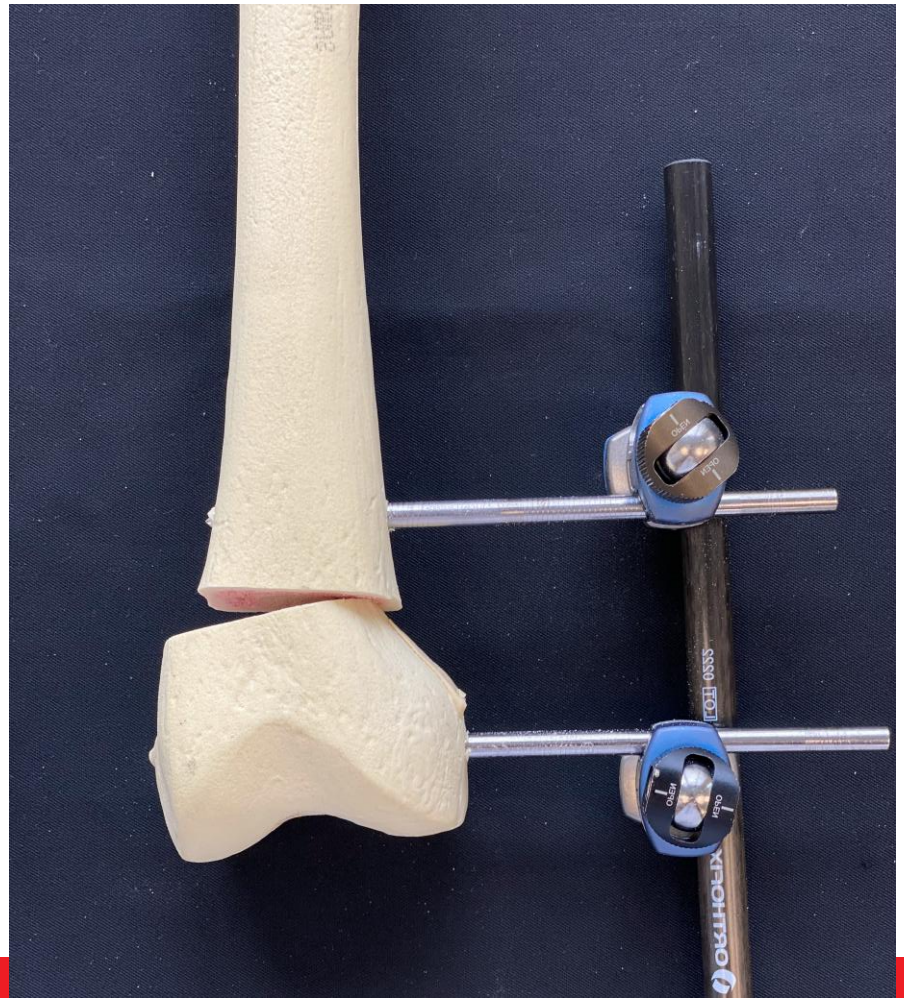


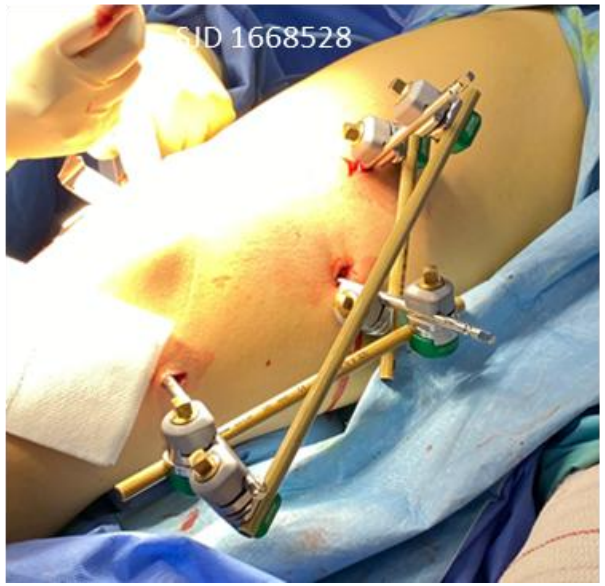
- **Lateral subvastus approach**
- **Osteotomy (saw)**
- **Correction sequence:**
  - Rotation → Translation → Angulation



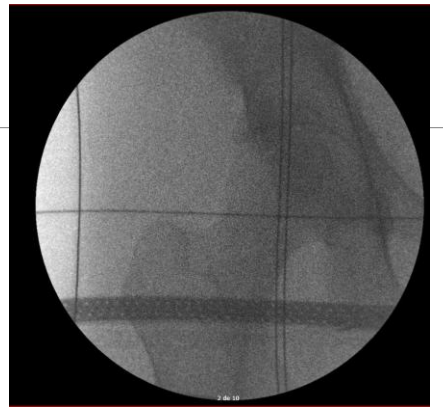


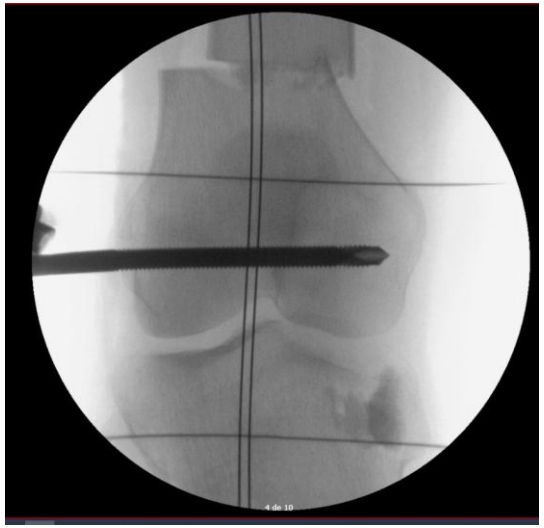
- **Final position locked by tightening the fixator**





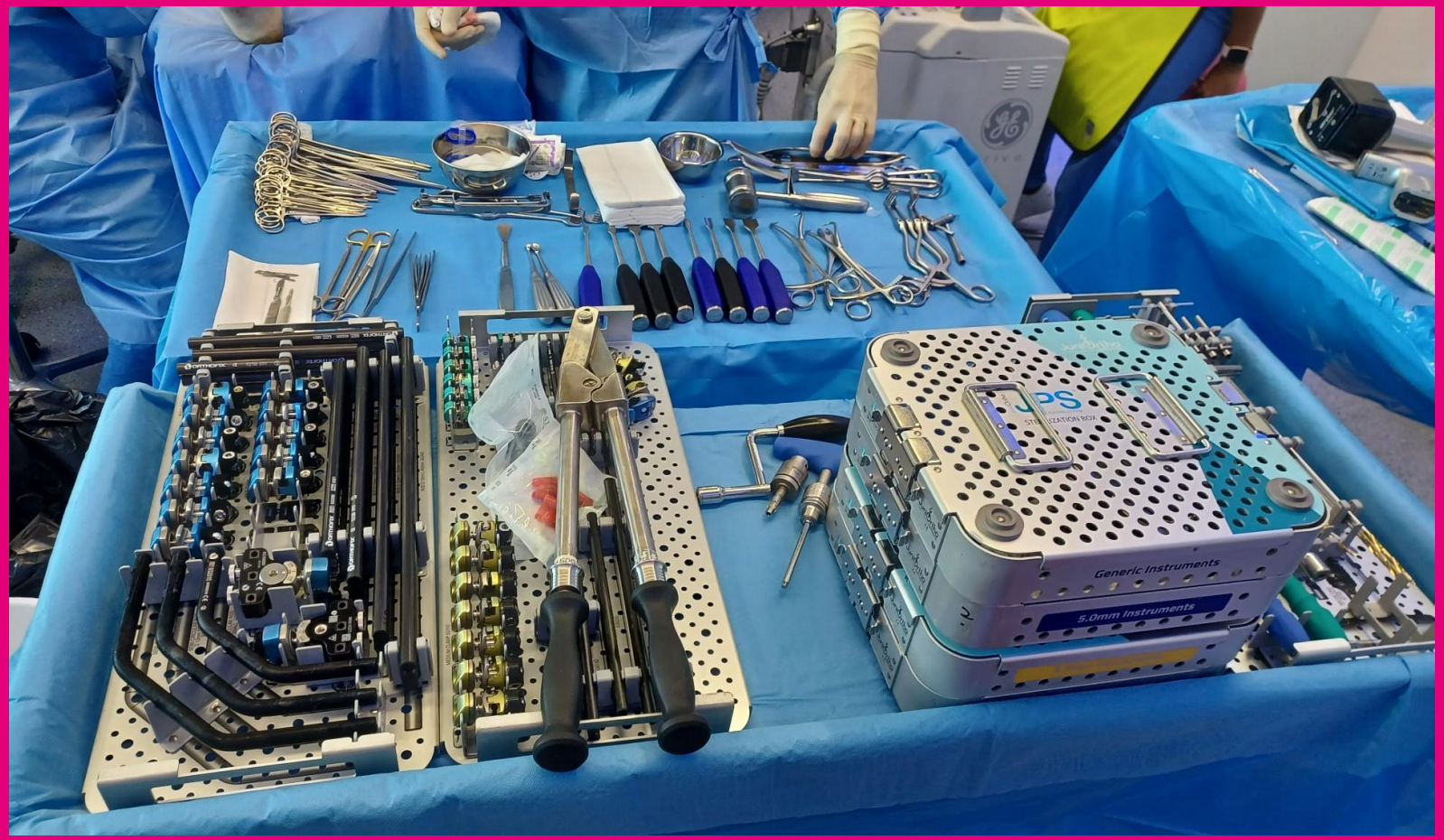
- It’s important to check the limb alignment multiple times.
- X Ray Grid or Bovie cord test can be used passing through the centre of the femoral head, knee, and ankle to confirm the perfect alignment
- And check the sagittal plane





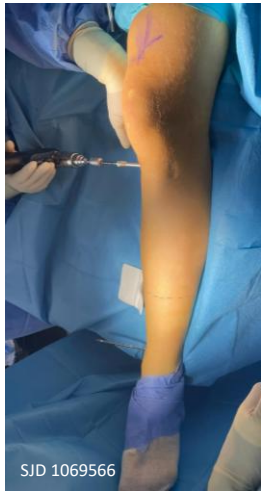
- Locking plate is inserted in the submuscularly and extraperiosteally
- The plate does not require being in full contact with the bone, plates are more symptomatically distal, don’t worry.
- Percutaneous screws allowed
- Bone graft may be added to the osteotomy site

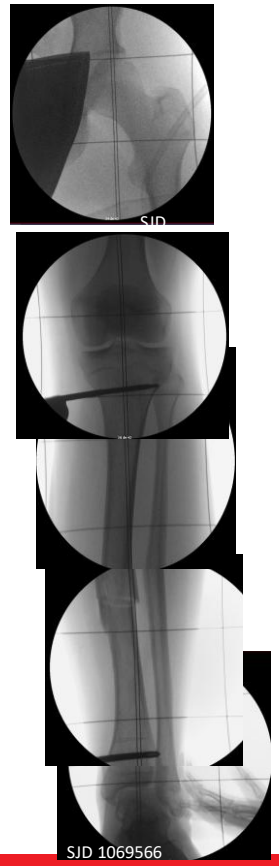
Group B: Tibial FALP technique



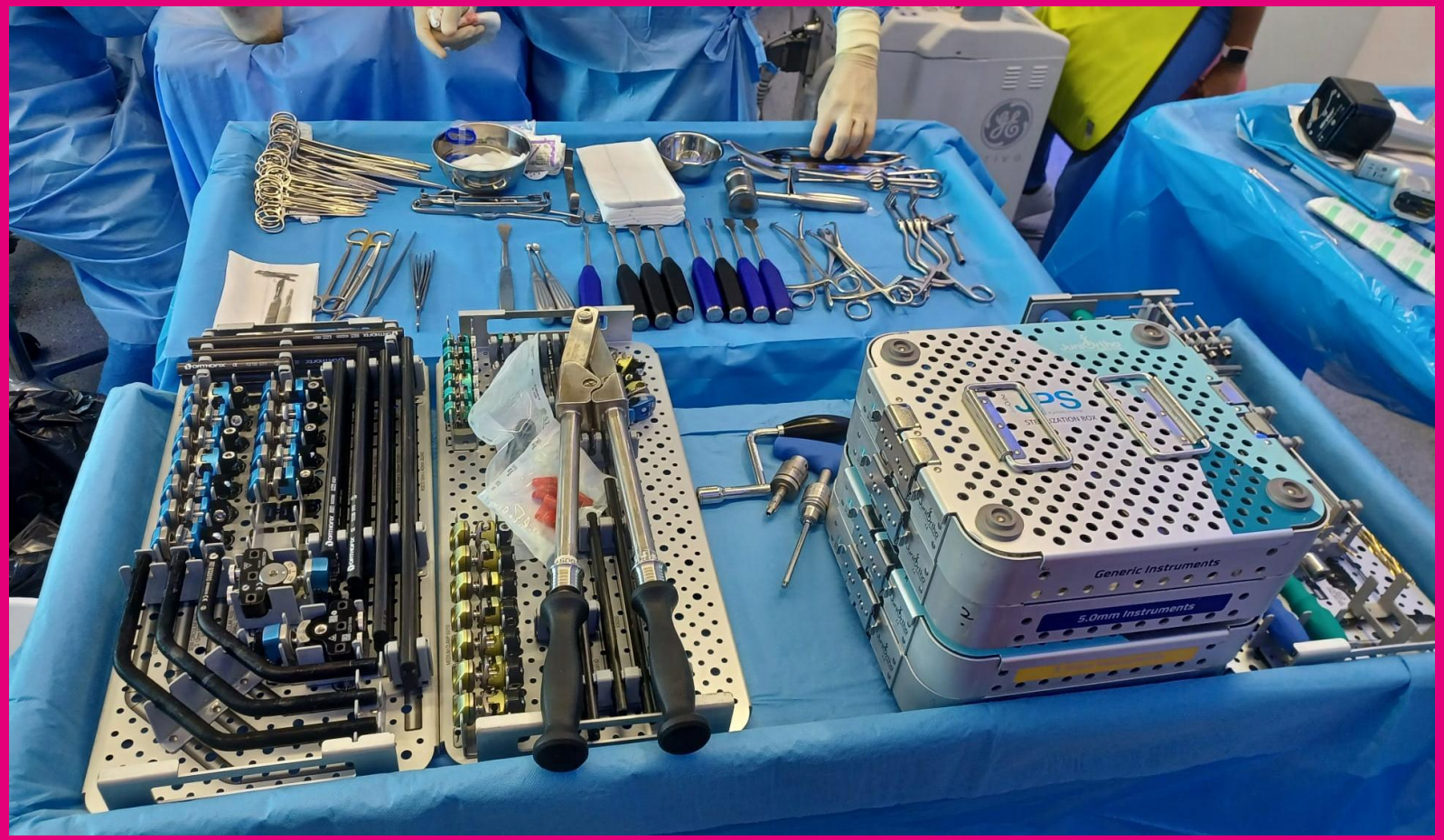
Tibial FALP technique

- Technique similar to distal femoral FALP (Group A)
- Pins can be placed either medial or anteriorly, depending on deformity and plate position

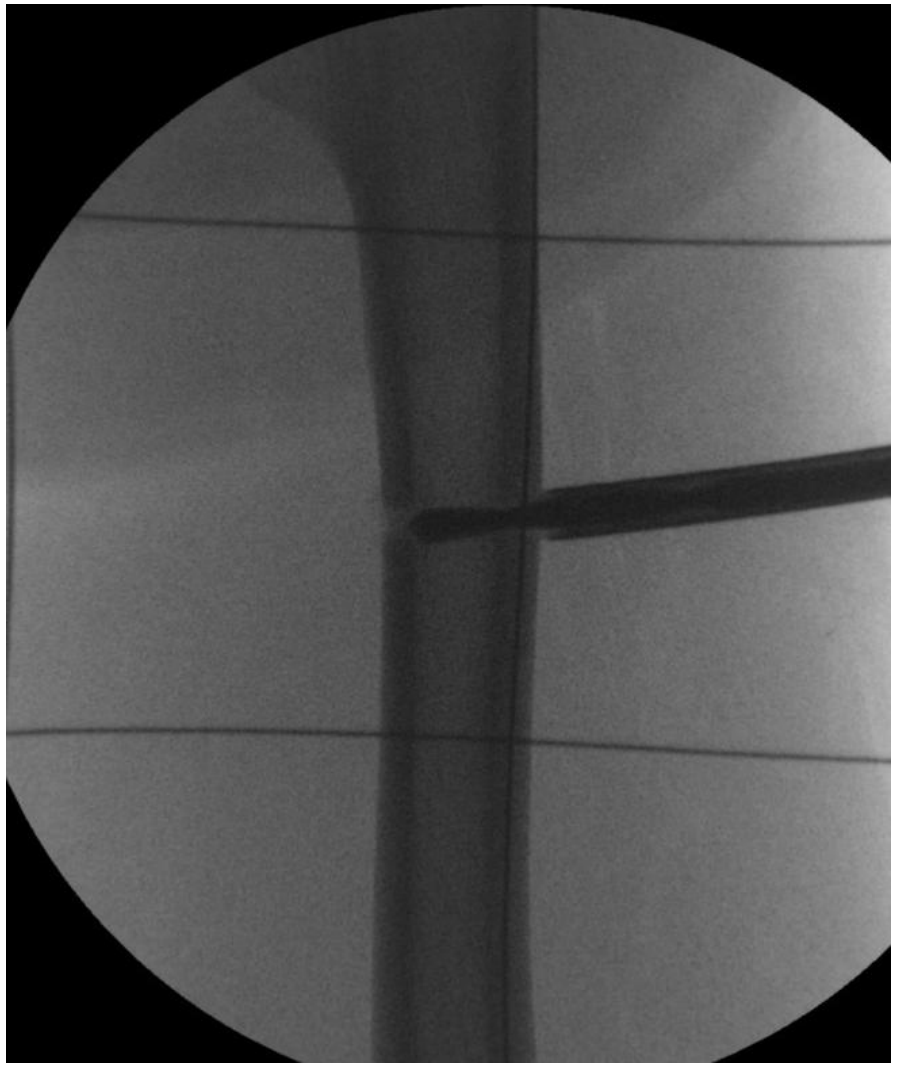




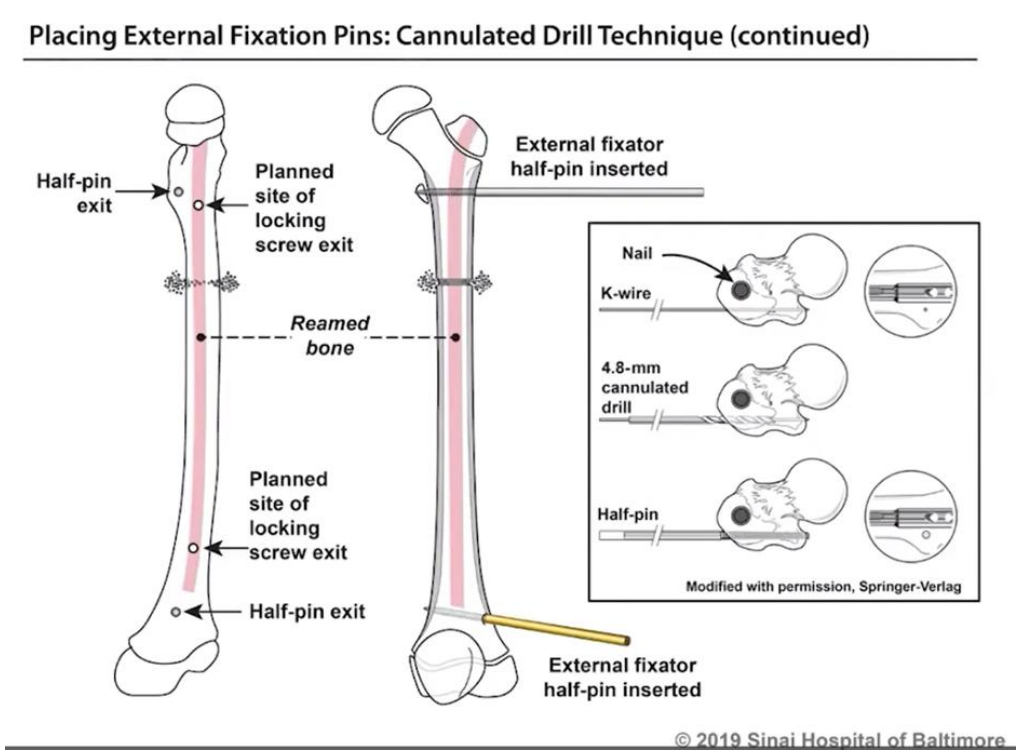
Group C: FAN technique

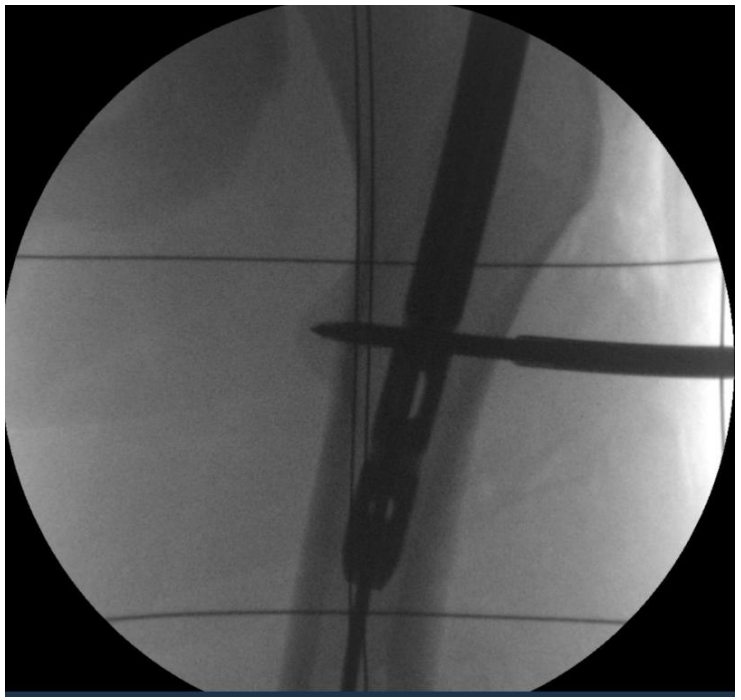


- **Pre-drilling osteotomy site before reaming to minimize fat embolism risk**

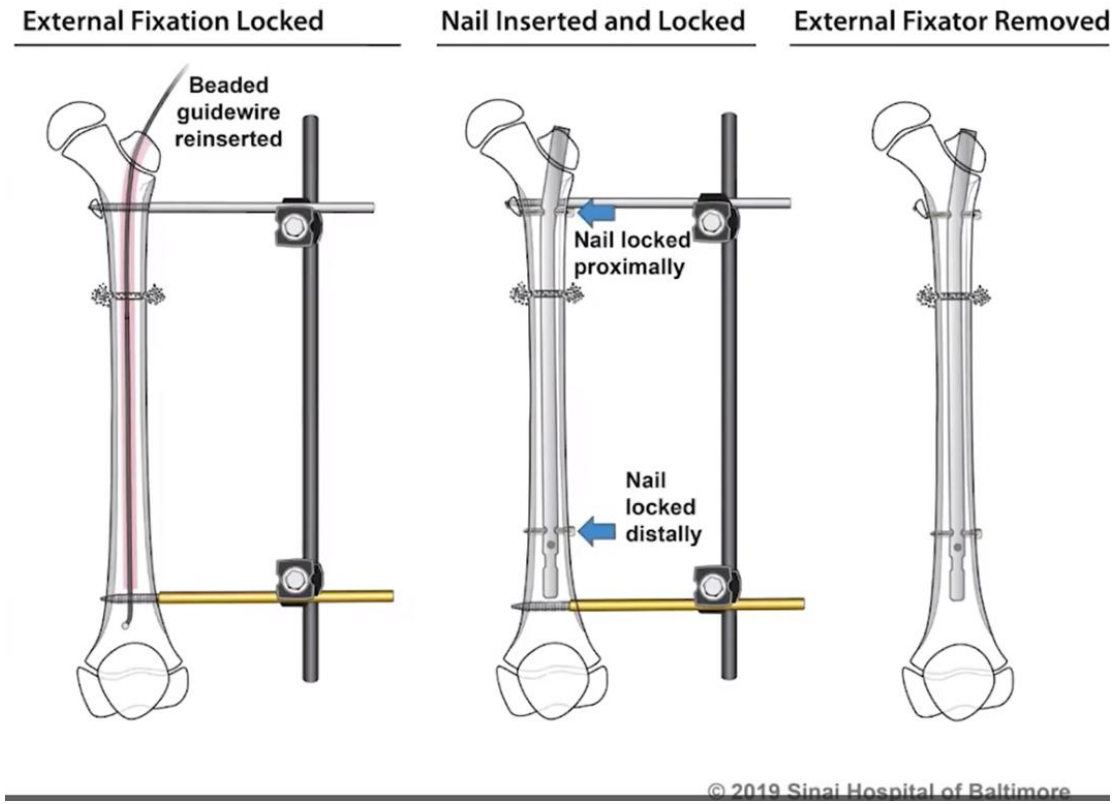


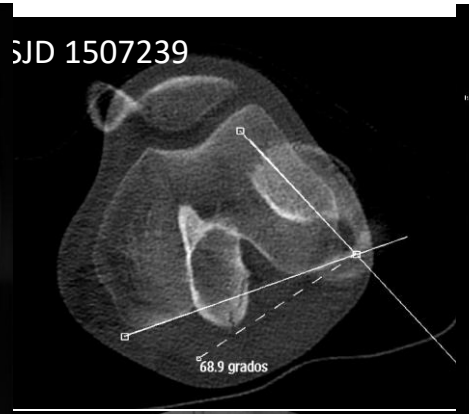
- **Careful placement of half-pins (avoiding nail path):**
  - Femur: Near lesser trochanter (antegrade) or posterior condyles (retrograde).
  - Tibia: Proximal tibia, posteriorly.
  - (with or without cannulated drill technique)

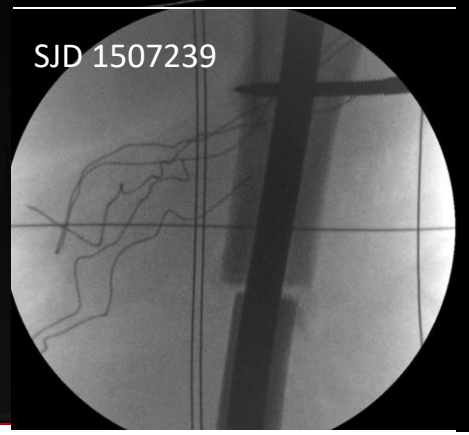




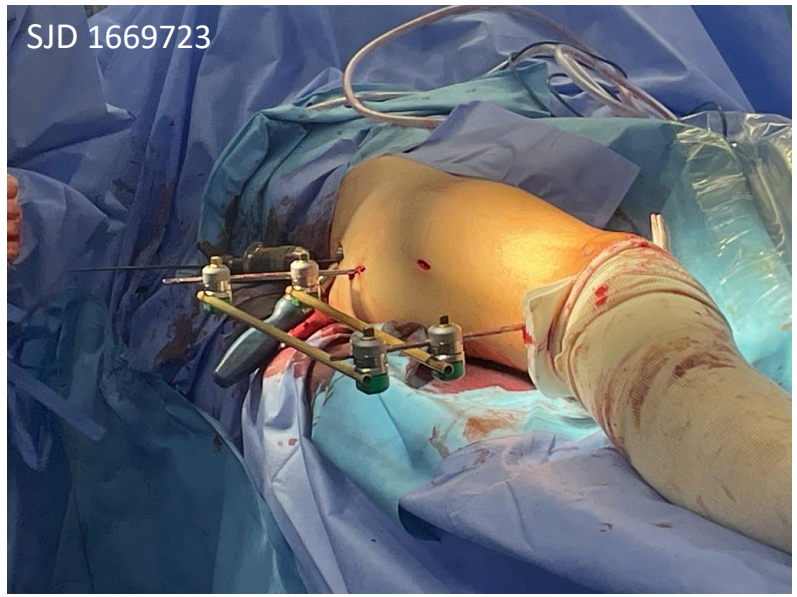
- **Deformity correction using external fixator.**
- **Intramedullary nail insertion and static locking (proximal and distal).**

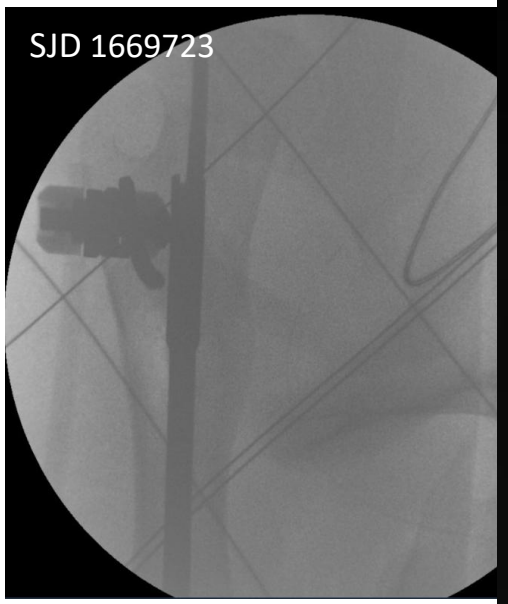


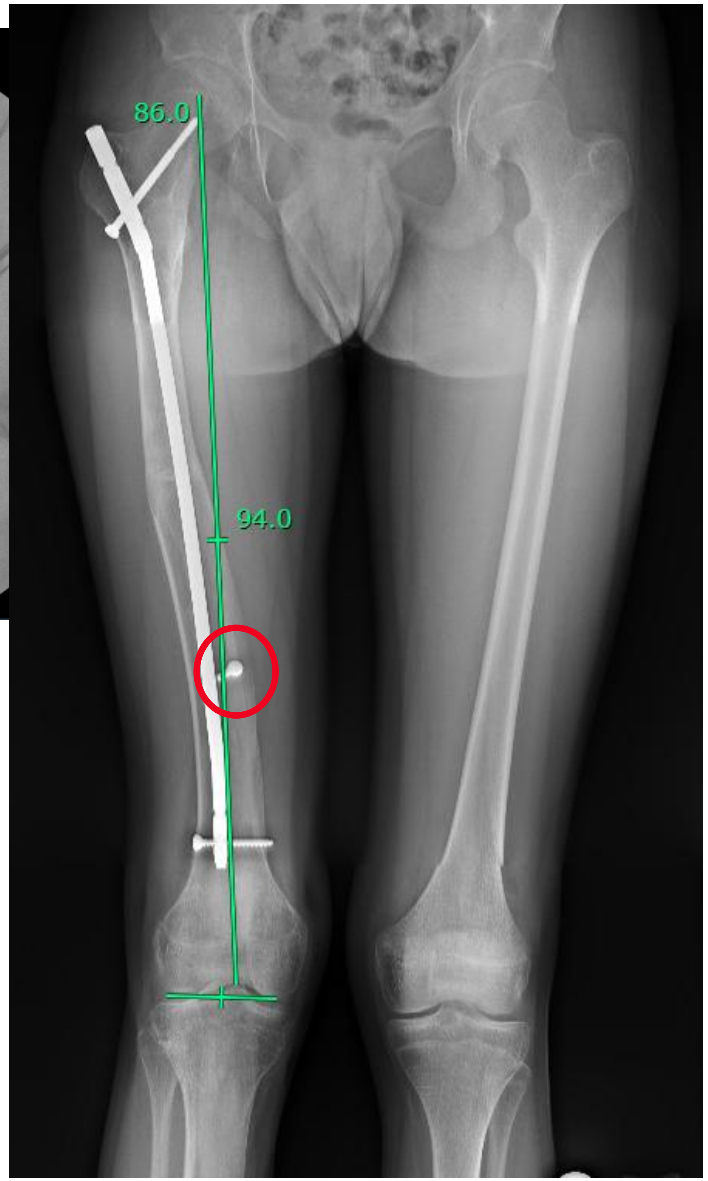




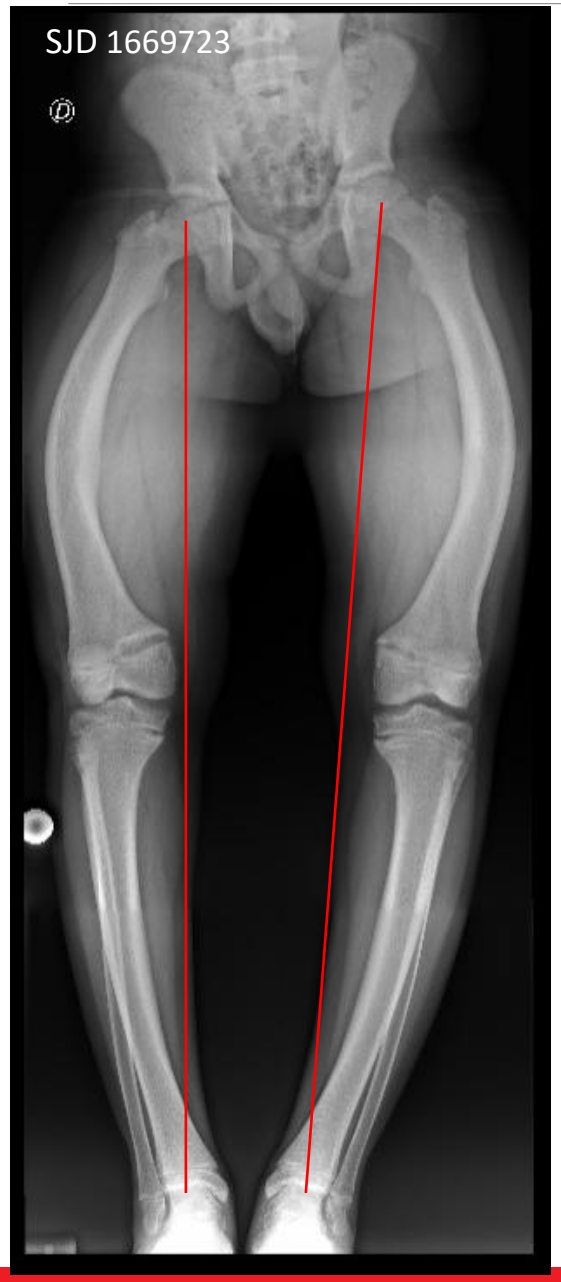
- **Poller screws used if needed.**

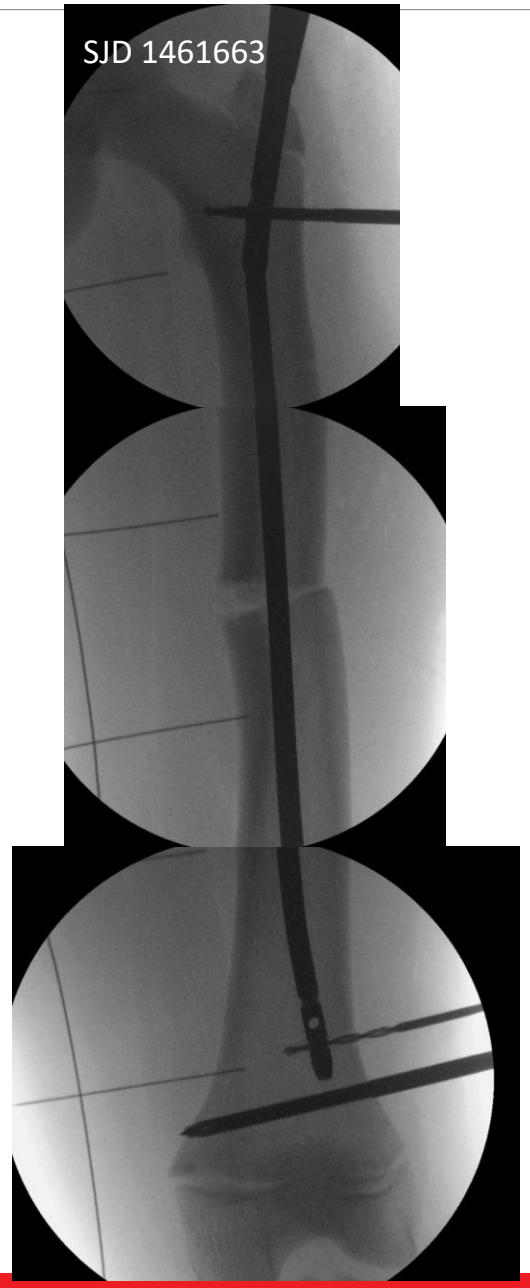


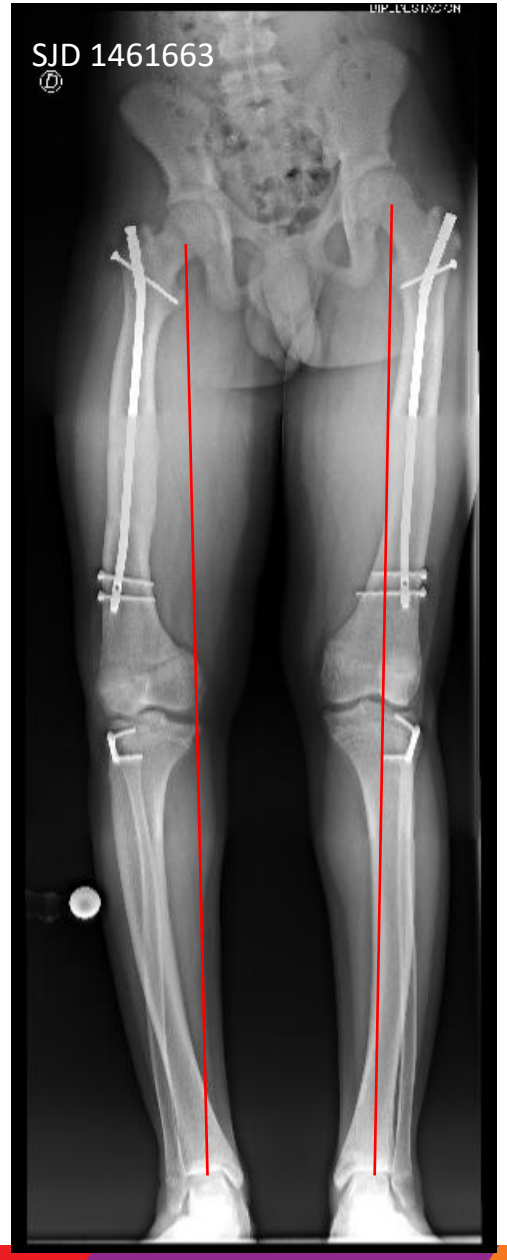




X-Linked hypophosphatemic rickets (FAN & FALP)







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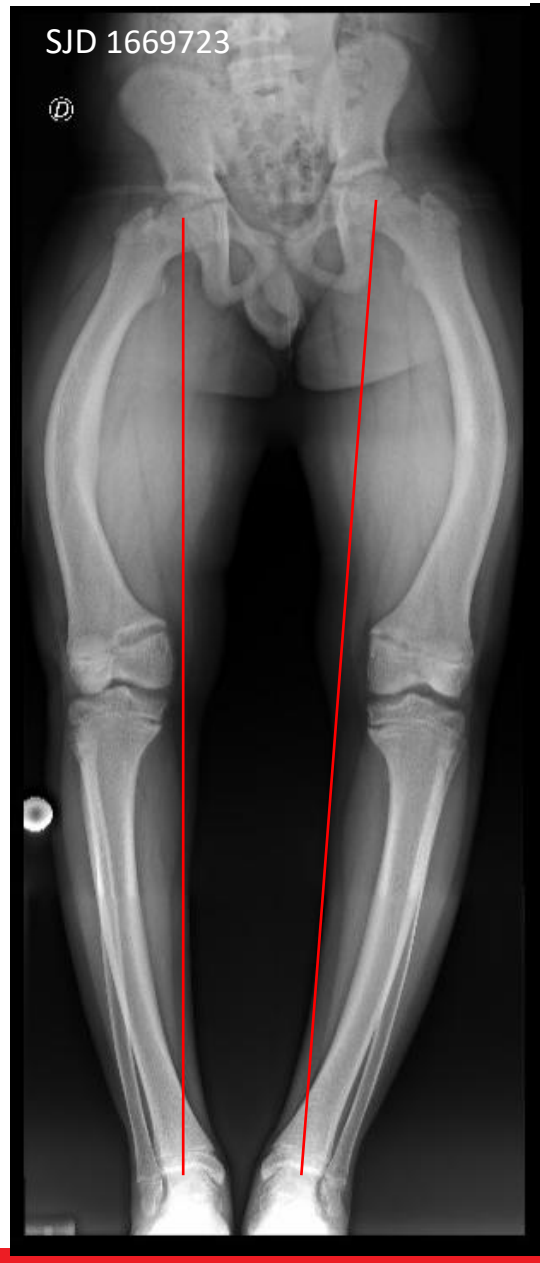
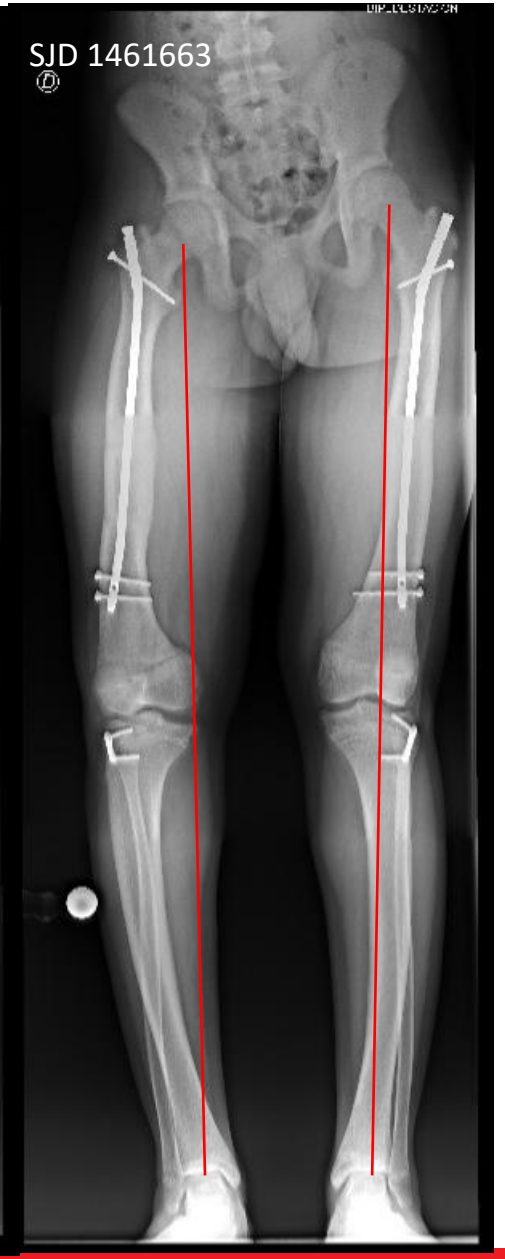
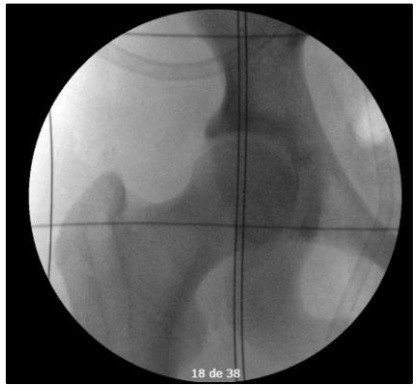
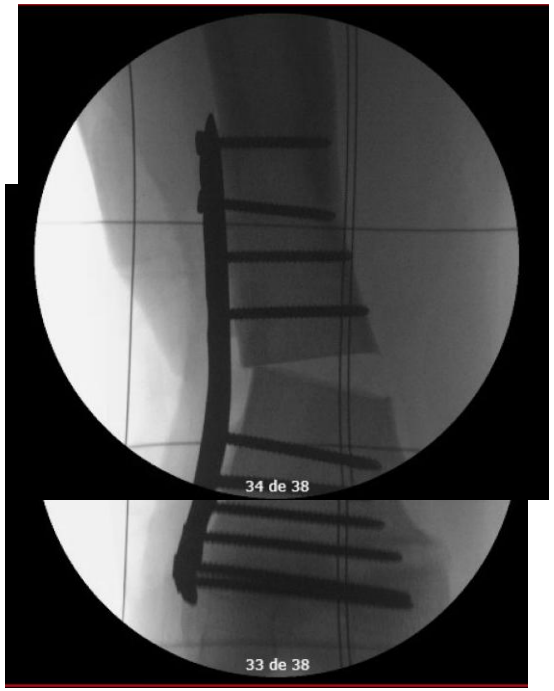








Results

Group	Surgical Time	Hospital Stay	Time to Weight-Bearing	Time to Bone Consolidation	Time to Resume Activities	Complications
Group A FALP n =21 (femora)	3h (SD 55m)	3.4 days (SD 1.0)	40.0 days (SD 10.5)	3.6 months (SD 1.0)	5.7 months (SD 1.9)	Plate loosening
Group B n=4 (tibiae)	2h 14m (SD 26m)	7 days (SD 7.3)	34.5 days (SD 14.4)	5.3 months (SD 3.6)	6.3 months (SD 3.2)	Wound dehiscence, compartment syndrome
Group C FAN n=6 (5 femora, 1 tibiae)	4h 28m (SD 1h 25m)	4.2 days (SD 0.8)	5.8 days (SD 6.8)	4.6 months (SD 1.5)	6.6 months (SD 2.5)	CPN injury
p-value	**0.006**	**>0.05**	**0.001**	**>0.05**	**>0.05**	**N/A**

Results

Group	Frontal				Torsional		Sagittal	
	Valgus		Varus		External	Internal	Hyperextension	Flexion
	MAD correction	mLDFA/MPTA correction	MAD correction	mLDFA/MPTA correction	External tibial torsion	Femoral anteversion	PDFA correction	PPTA correction
Group A	N=12		N=5			N=3	N=1	
FALP	36.7 mm (SD 13.4)	12.1º (SD 5.8)	36.4 mm (SD 15.5)	14.9º (SD 8.5)	N/A	53.3º (SD 23.6)	22º	N/A
n =21 (femora)								
Group B					N=3			N=1
n=4	N/A	N/A	N/A	N/A	36.3º (SD 11.8)	N/A		10º
(tibiae)								
Group C	N=2		N=2			N=2		
FAN								
n=6	18.5 mm (14mm-23mm)	6.1º (4.2º - 8.1º)	22.5 (8-37mm)	6.6º (6.3-6.9º)	N/A	42.5º (SD 3.5)	N/A	N/A
(5 femora, 1 tibiae)								

Results

✅ **All correction goals** were achieved in every patient (MAD, mLDFA, MPTA, torsional and sagittal alignment).

🦴 **Radiological union** confirmed in **100%** of cases.

❌ **No secondary deformities**, **no joint stiffness**, and **no relevant leg length discrepancies** were observed.

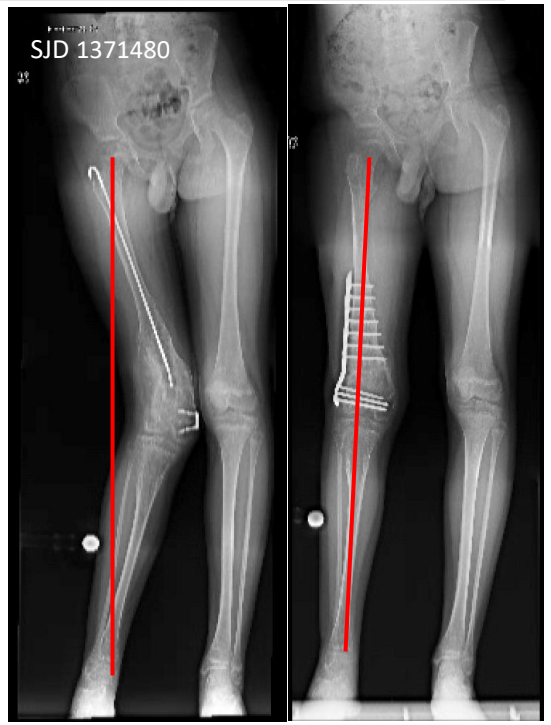
⚠️ **Complications** were rare and not related to the use of external fixation.

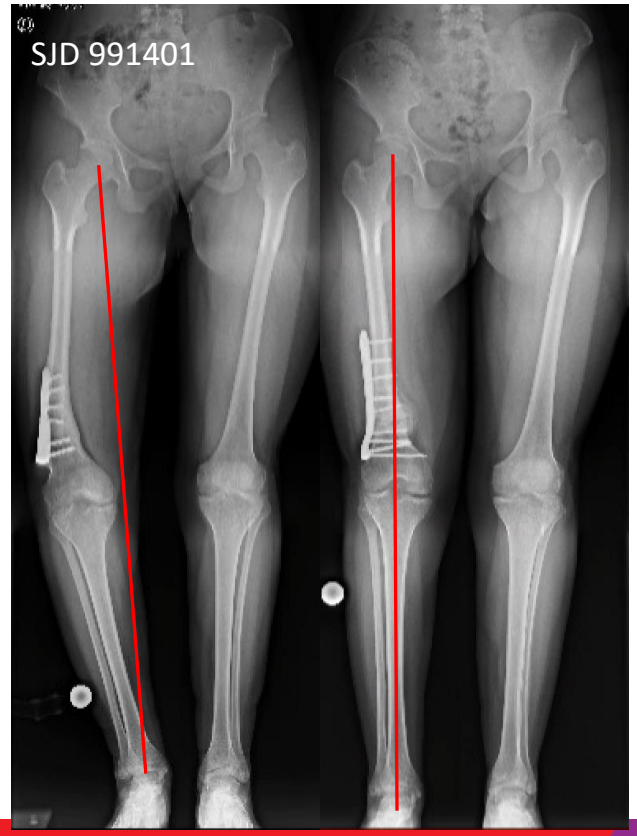
⏱️ **Mean follow-up: 14.8 months** (range up to 29 months).

🔧 **Implant removal** was performed in 32% of cases, relieving discomfort when present.

Discussion

- **Valgus deformities**: Our series achieved **high MAD and angular corrections**, comparable or superior to previous studies.
- **Varus corrections**, underrepresented in the literature, were also successfully corrected with substantial values.

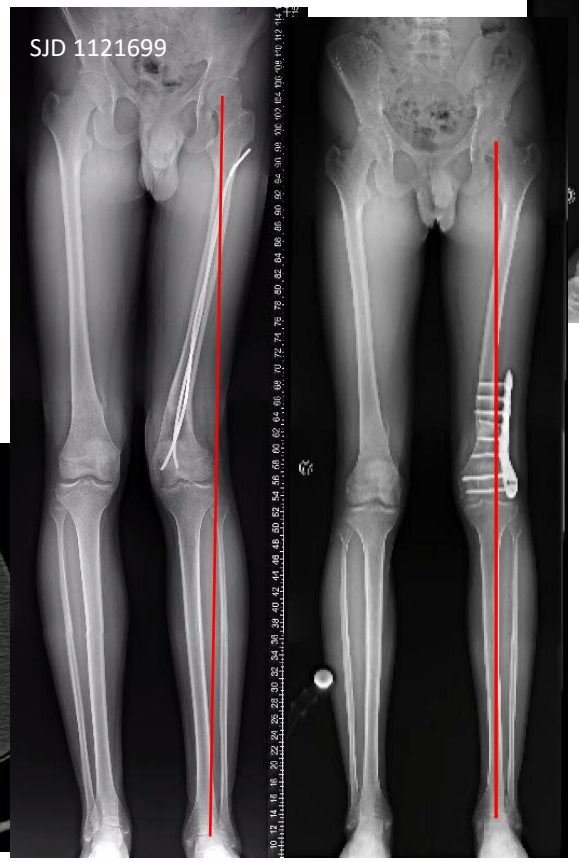


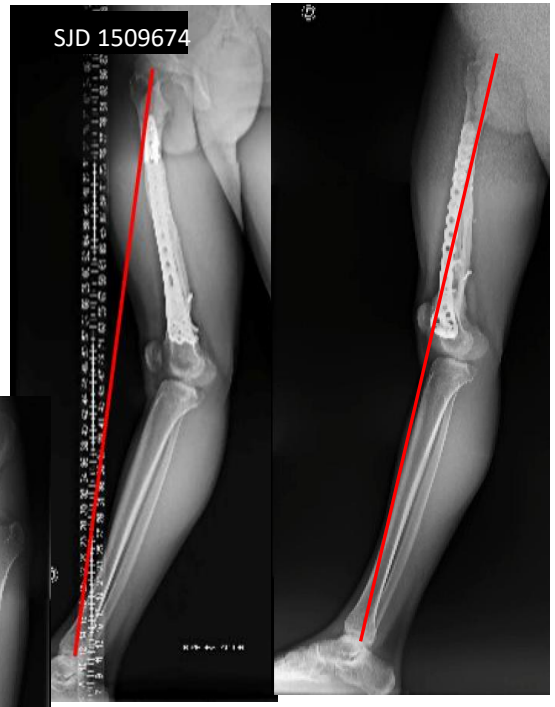


Correction	Rovira et al. (FALP)	Eidelman et al.	Yılmaz et al.	Bar-On et al.	Malik et al.	Rozbruch et al.
MAD Correction – Valgus (mm)	27–73	10–28	23–98	✗	10 (mean)	10 (mean)
mLDFA Correction – Valgus (°)	6.2°–23°	9°–14°	8°–28°	13°–18°	13°–18°	13°–18°
MAD Correction – Varus (mm)	16–55	✗	✗	✗	✗	✗
mLDFA Correction – Varus (°)	5.3°–27.6°	✗	✗	10°–14°	✗	✗

Discussion

Correction	Rovira et al. (FALP)	Bar-On et al.
Rotational Correction – Femur (°)	35°–80° (mean 53.3°)	30°–45°
Rotational Correction – Tibia (°)	29°–50° (mean 36.3°)	30°–45°
Sagittal Correction – Femur (°)	22° hyperextension	15°–40° hyperextension
Sagittal Correction – Tibia (°)	10° flexion	✗





Conclusion

- Fixator-assisted techniques such as FALP and FAN:
  - provide **accurate, versatile, and safe options** for the acute correction of complex multiplanar lower limb deformities in adolescents.
  - representing a valuable alternative to gradual correction methods in appropriately selected cases.

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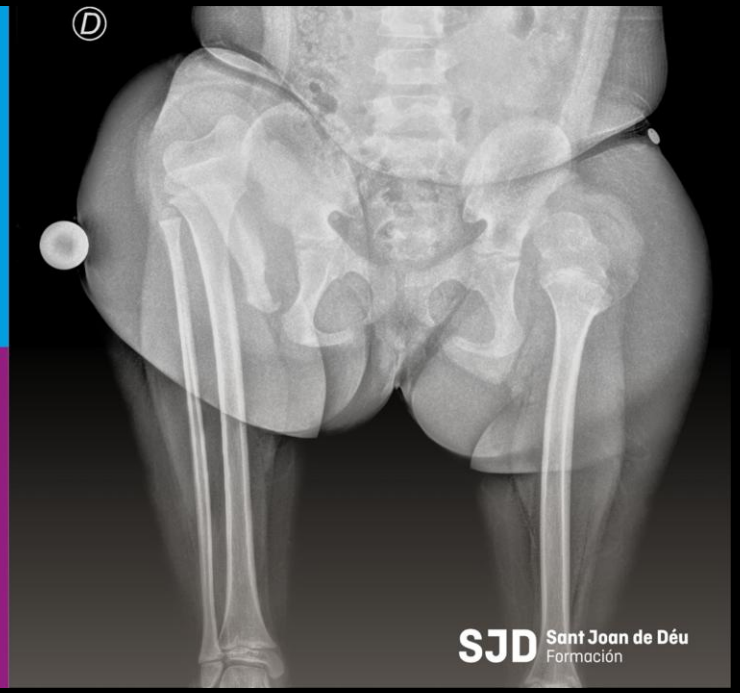

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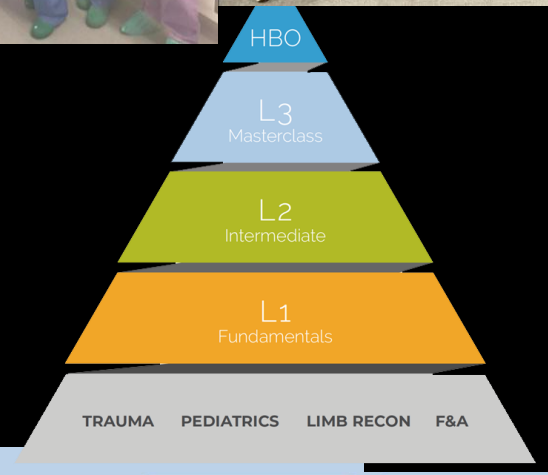
November 19-22, 2024

Hospital Sant Joan de Déu
Barcelona, Spain

Faculty:
Cesar Galo Garcia Fontecha, MD PhD
Maria Pilar Rovira Marti, MD



1 - 3 Jul 2025 PED

Pediatric Limb Reconstruction Procedures
In Person Course

VERONA ITALY
Language: English

Invited Faculty